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107-6579-JWH
January 21, 2011

Ms. Christine Kump-Mitchell, P.E.
Environmental Engineer, Permits Section
Missouri Department of Natural Resources
Hazardous Waste Program
7545 South Lindbergh
St Louis, MO 63125

BOEING

Re: Boeing Tract I Groundwater Monitoring

Dear Ms. Kump-Mitchell:

The attached report presents a comparison of groundwater monitoring results from samples obtained by the use of Snap Samplers and low-flow sampling methods. This pilot study was conducted during the April and October, 2010 groundwater monitoring events to evaluate the possibility of site wide application of Snap Samplers.

The results indicate an acceptable comparison between the concentrations obtained from analysis of groundwater samples collected using Snap Samplers and low-flow purging and sampling methods. Therefore, we recommend that future groundwater sampling of all wells, except those less than two inches in diameter, be conducted using Snap Samplers. Based on your comments and approval we would like to use the Snap Samplers for future groundwater monitoring events at the Boeing Tract I site.

Please contact me or our consultants, Atul Salhotra or Kendall Pickett at 713-784-5151, if you have any questions.

Sincerely,

Joe Haake
Environmental Scientist
(314) 777-9181

CC: Mr. Rich Nussbaum, MDNR
Mr. Bruce Stuart, MDNR
Ms. Amber Whisnant, USEPA, Region VII
Ms. Joletta Golik, City of St. Louis Lambert International Airport
Mr. Atul Salhotra, RAM Group

COMPARISON OF GROUNDWATER CONCENTRATIONS USING SNAP SAMPLER AND LOW-FLOW PURGING AND SAMPLING

Boeing Tract 1 Facility, Hazelwood, Missouri

1.0 OBJECTIVE OF THE STUDY

During the April-May and October-November, 2010 groundwater monitoring events the Snap Samplers were installed at ten groundwater monitoring wells at Boeing Tract 1 Facility, Hazelwood, Missouri. Photographs of Snap Samplers and installations are included in Appendix A. The location of these monitoring wells is shown in Figure 1. The objective of this pilot study was to evaluate the site-specific effectiveness of Snap Samplers and identify the possibility of site wide implementation of Snap Samplers.

2.0 BRIEF BACKGROUND ON SNAP SAMPLERS

Evaluations of the Snap Sampler technology have been conducted by the Department of Defense through their Environmental Security Technology Certification Program (ESTCP) for a variety of chemical constituents (Parker et al., 2007, 2008, 2009). These studies suggest that the chemical recovery and hence the concentrations recorded using Snap Samplers were comparable to low-flow purging and sampling. Peer-reviewed literature also explains that a Snap Sampler can be used for any compound (Britt et al. 2010). Several relevant references are included in Section 5.0.

The Snap Sampler method is anticipated to be equivalent, and in fact an improvement on the current low-flow purging and sampling approach. A few specific advantages are discussed below:

1. Snap Samples are sealed in situ without headspace, meaning sample is usually not exposed once retrieved, and is submitted to the laboratory in the same container that the sample is collected. This reduces any loss of volatiles.
2. Reduced possibility of cross contamination since each well essentially has a dedicated Snap Sampler as opposed to bladder pump setup that is used at several wells for low-flow purging and sampling.
3. Reduced inter sampling event variability compared to low-flow purging and sampling. In case of low-flow purging and sampling, the purge volume and sampling flow rate vary from event to event and from well to well. These variabilities are not there in Snap Sampler method.
4. Snap Samples are collected from the same interval during each sampling event.
5. Groundwater samples obtained using Snap Samplers are representative of equilibrium conditions whereas it is difficult to achieve equilibrium conditions during low-flow purging and sampling at several wells such as wells with low yield. In case of Snap

Samplers, the equilibrium is achieved over a period of six months between the sampling events.

6. Snap Samplers might prove effective for low-yielding wells where the water level in the well drops significantly even when using a very low purging flow rate.
7. Snap Samples tend to have less "random error" which provides better quality data to evaluate concentration trends (Britt 2007, pp 21).
8. Reduced waste generation consistent with "green remediation and investigation" initiative. No purge water waste is generated that requires containment, transportation, disposal, and / or recycling. Solid waste is minimized. Decontamination of equipment is minimal, usually only needed for the water level measuring device, which typically is done with spray bottles and paper towels.
9. Significant reduction in time required for sampling resulting in cost savings.

Once the sample has been collected, same laboratory protocols are used to analyze samples. Thus the only difference between the two methods is the manner in which the samples are collected. From a compliance standpoint, the method has been shown to be equivalent to traditional purge sampling approaches in many studies dating back to 2004 (Section 5). Snap Samplers have been or are being used in several states for site characterization and compliance monitoring. An evaluation of Snap Samplers was conducted in Missouri by Raymond Franson of MDNR. Personal conversation with Mr. Franson on January 10, 2011 provided further insight that Snap Samplers provide better data over low-flow purging and sampling.

Snap Samplers cannot be used at wells where large sample volumes are necessary for several laboratory analytical methods. Although there is sufficient evidence that Snap Samplers provide consistent, representative, and superior results, a pilot study was conducted to evaluate the site-specific applicability of Snap Samplers.

3.0 DATA EVALUATION

The groundwater concentration data obtained using Snap Samplers at the ten wells is compared to the data collected by low-flow purging and sampling method. The following data was not used for comparison:

1. Monitoring well SWMU17-OB-1 in the southeast corner of the backfill is screened from 0 to 11.75 ft bgs. The groundwater flow in this area is generally towards the southeast. Therefore the Snap Samplers capture groundwater which is representative of the backfill (upgradient). In case of low-flow purging and sampling, the purge water is drawn from a radial direction and will include both the backfill and the formation. The samples collected by the two methods represent different groundwater. Therefore, SWMU17-OB-1 concentration data is not used in the comparison.
2. During October-November 2010 groundwater monitoring event, problems were encountered at MW3 with the pneumatic actuator that triggers the sampler line which

closes the sample bottle caps. Hence, the Snap Samplers were retrieved without collecting groundwater samples. The Snap Samples were collected after lowering the Snap Sampler which might have created some turbulence in the well. Therefore, MW3 concentration data collected during October-November 2010 groundwater monitoring event was not used in the comparison.

3. During October-November 2010 monitoring event, manganese concentration in Snap Sample at B4MW-9 was twice that in the low-flow sample. The Snap Sample concentration was indicated to have a spike recovery problem in the laboratory analysis and was indicated with an "S" flag by the laboratory (RAM 2010).
4. During October-November 2010 monitoring event, arsenic concentration at MW10D was 42 µg/L in the low-flow sample and was below detection in Snap Sample. The higher concentration in the low-flow sample might be due to high turbidity of the low-flow sample (RAM, 2010).

3.1 Comparison of Volatile Organic Compounds Concentrations

Table 1 presents the VOCs concentrations for the two groundwater monitoring events. Only the COCs that had at least one detected concentration were included in the evaluation. Figures 2(a) and 2(b) present a comparison of VOC concentrations obtained from both Snap Samplers and low-flow method for April and October 2010 events, respectively. Figure 2(c) presents the comparison of Snap Samples with low-flow samples for both events. The following table shows the correlation coefficients and the ratio of concentrations.

Data	Correlation Coefficient (R^2)	Ratio
April-May 2010	1.0	1.09
October-November 2010	0.98	0.87
Both Events	1.0	1.09

The above analysis indicates an excellent comparison between the two sampling approaches.

3.2 Comparison of Metals Concentrations

Table 2 presents the metals concentrations for both groundwater monitoring events. Figures 3(a) and 3(b) present a comparison of concentration of metals for April and October 2010 monitoring events, respectively. During October 2010 event, only arsenic and manganese were analyzed. Figure 3(c) presents a comparison of metal concentrations for both events. The following table shows the correlation coefficients and the ratio of concentrations.

Data	Correlation Coefficient (R^2)	Ratio
April-May 2010	0.88	1.09
October-November 2010	0.69	0.95
Both Events	0.90	1.0

The above analysis indicates an good comparison between the two sampling methods.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The comparison of Snap Samplers to low-flow purging and sampling indicate a good correlation between the two methods except for samples with specific issues as mentioned above. The comparison does not indicate any systematic bias between the two methods. Although the study included only ten wells and two monitoring events, the results are consistent with the literature and other pilot studies.

Based on the above, we recommend site-wide implementation of Snap Sampler method for future groundwater monitoring with few exceptions noted below. Note Snap Samplers will not be installed at

- One inch diameter wells since a minimum of 2 inch diameter is required for Snap Samplers.
- Wells with LNAPL since LNAPL might cross contaminate the Snap Samples.
- Wells with any obstructions (e.g. kinked casing)

5.0 REFERENCES

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Raymond Franson, Advantages of Passive Sampling Methods for Groundwater Sampling at Hazardous Waste Remediation Sites
http://www.astswmo.org/files/meetings/2008FFSymposium/Franson.pdf

Technology Developer Website: www.SnapSampler.com

Table 1
Comparison of Detected VOC Concentrations in Groundwater (ug/L)
Boeing Tract 1, Hazelwood, Missouri

Sample	MW-A28 (1)				MW-11S (2B)				MW3 (6B)				MW6 (6D)				MW10S (8A)				MW10D (8A)				SWMU17-OB-1* (2B)			
	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD
April-May, 2010	**5/3/2010**				**4/29/2010**				**4/29/2010**				**4/26/2010**				**4/26/2010**				**4/26/2010**				**4/29/2010**			
1,2-Dichloroethene, Total									14,000	13,000	1.1	7													*1.1*	5.45	0.2	133
Acetone	*13*	*18*	0.7	32																								
cis-1,2-Dichloroethene									14,000	12,800	1.1	9													*1.1*	*3.9*	0.3	112
Naphthalene	*2*	*4.8*	0.4	82																								
tert-Butylbenzene	*1.3*	*1.6*	0.8	21																								
Tetrachloroethene													*2.8*	*3.4*	0.8	19												
Trichloroethene					*4.5*	*3.7*	1.2	20					*1.3*	*1.4*	0.9	7					8.2	*4.1*	2.0	67				
Vinyl chloride									1,080	953	1.1	12					*1.4*	*1.3*	1.1	7					*1.2*	15.9	0.1	172
October-November, 2010	**11/3/2010**				**10/29/2010**				**11/2/2010**				**10/25/2010**				**10/25/2010**				**10/25/2010**				**11/1/2010**			
1,1-Dichloroethane																	*1.6*	*2.4*	0.7	40								
1,2-Dichloroethene, Total									10,500	16,600	0.6	45													< 5	16.7		
Acetone													< 25	*5.1*														
Benzene	2.3	2.4	1.0	4																								
cis-1,2-Dichloroethene									10,400	16,500	0.6	45													< 5	16.7		
Isopropylbenzene	27	29.9	0.9	9																								
Naphthalene	*6.8*	12.2	0.6	57																								
n-Butylbenzene	< 5	10.7																										
n-Propylbenzene	32	36.4	0.9	13																								
sec-Butylbenzene	8.6	9.8	0.9	13																								
tert-Butylbenzene	*1.6*	*1.6*	1.0	0																								
Tetrachloroethene													*2*	*1.7*	1.2	16												
trans-1,2-Dichloroethene									*120*	*180*	0.7	40																
Trichloroethene					*3.8*	*2.6*	1.5	38													5.3	*2.4*	2.2	75				
Vinyl chloride									917	1,130	0.8	21					*1.4*	*1.5*	0.9	7					< 2	24.7		
Xylenes, Total	*1.1*	*1.1*	1.0	0																								

Notes
All concentrations are in µg/L
Values in italics are concentrations estimated below the reporting limt (with "J" qualifier)
SS: Snap Sample
LF: Low-flow sample
Blank fields indicate that the chemical was not detected by either sampling methods
None of the VOCs were detected at MW-11I, MW-8AS, and B4MW-9
Ratio = Snap Sample concentration/Low-flow sample concentration
RPD: Relative percentage difference

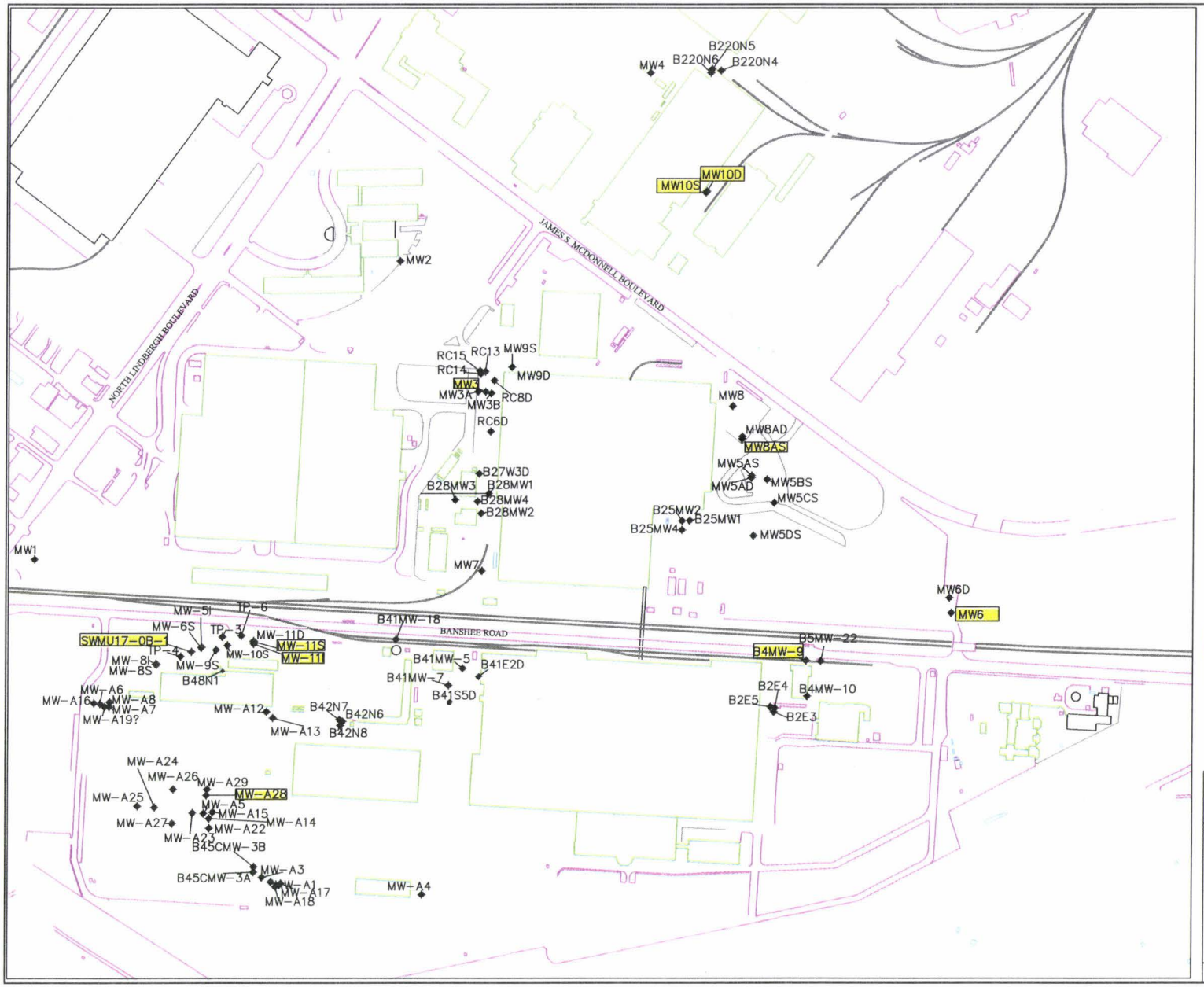
$$RPD = \left| \frac{SS - LF}{(SS + LF) \div 2} \right| \times 100$$

Table 2
Comparison of Detected Metal Concentrations in Groundwater (ug/L)
Boeing Tract 1, Hazelwood, Missouri

Sample	MW-11S (2B)				B4MW-9 (3H)				MW3 (6B)				MW-8AS (6C)				MW10S (8A)				MW10D (8A)			
	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD	SS	LF	Ratio	RPD
April-May, 2010	4/29/2010				NA				4/29/2010				4/26/2010				4/26/2010				4/26/2010			
Arsenic									32.8	*20*	1.6	48					31.7	25	1.3	24				
Barium									743	726	1.0	2	370	395	0.9	7	244	216	1.1	12	323	315	1.0	3
Cadmium													*0.4*	*0.3*	200	29								
Chromium									*4.2*	*4.4*	1.0	5	*5.7*	*6.7*	0.9	16	10	5.2	1.9	63	10.1	*6.8*	1.5	39
Manganese									2,650	2,690	1.0	1	3,050	1,760	1.7	54	1,920	2,080	0.9	8	500	948	0.5	62
Barium, Dissolved									536	672	0.8	23												
Manganese, Dissolved									2,380	2,620	0.9	10												
October-November, 2010	10/29/2010				11/2/2010				11/2/2010				10/26/2010				10/25/2010				10/25/2010			
Arsenic	13	< 25							*10*	< 25											< 25	42.2		
Manganese					3,900 S	1,800	2.2	75	2,620	2,500	1.0	5	2,660	3,130	0.8	16	1,960	1,810	1.1	8	1,650	1,880	0.9	13

Notes
All concentrations are in µg/L
None of the metals were detected at MW-A28, SWMU17-OB-1, MW-11I, MW-6
NA: Snap Sampler was installed for November 2010 groundwater monitoring
Values in italics are concentrations estimated below the reporting limt (with "J" qualifier)
SS: Snap Sample
LF: Low-flow sample
Blank fields indicate that the chemical was not detected by either sampling methods
Ratio = Snap Sample concentration/Low-flow sample concentration
RPD: Relative percentage difference

$$RPD = \left| \frac{SS - LF}{(SS + LF) \div 2} \right| \times 100$$



N

LEGEND

- Groundwater Monitoring Well
- Railroad
- Roadway
- Building Outline
- Wells with Snap Samplers

0 400

APPROX. SCALE (FEET)

RAM Group of Gannett Fleming, Inc.
5433 Westheimer, Suite 725, Houston, TX

Figure 1
Location of Monitoring Wells
(Shallow, Intermediate, and Deep Zones)
Boeing Tract 1
St. Louis, Missouri

November 2010/BR | RAM Group (049992)

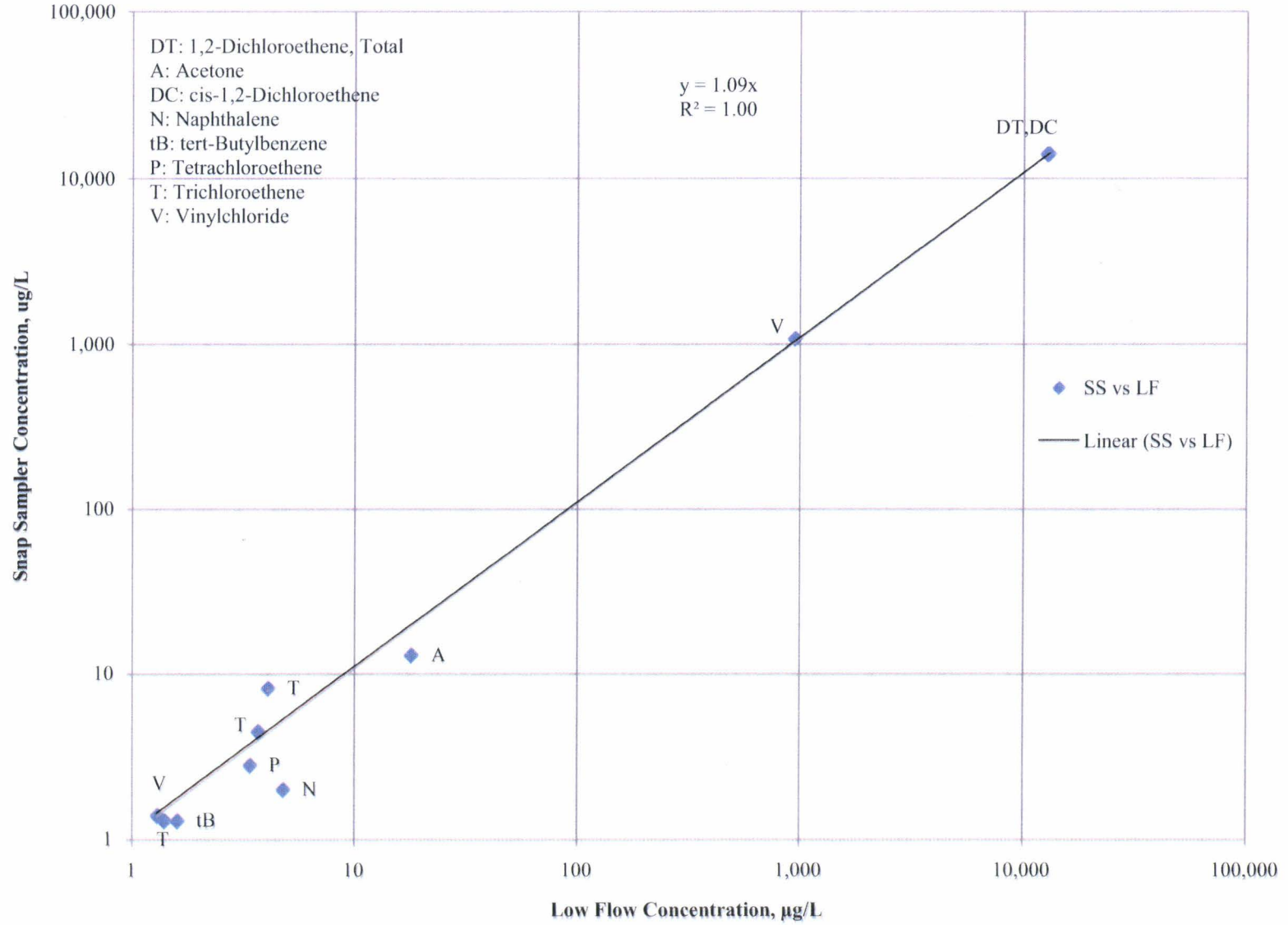


Figure 2(a): Comparison of VOC Concentrations, April 2010

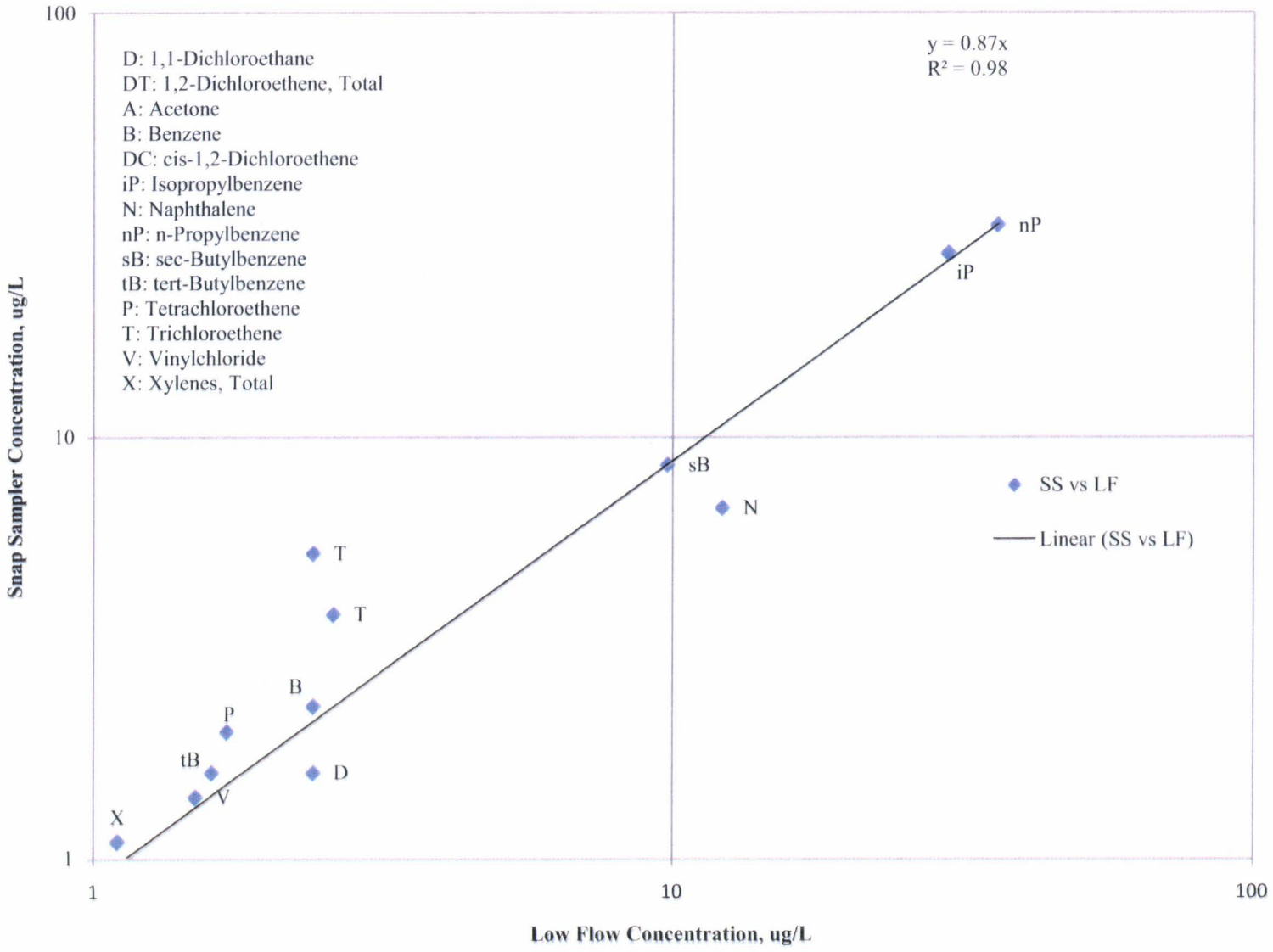


Figure 2(b): Comparison of VOC Concentrations, October 2010

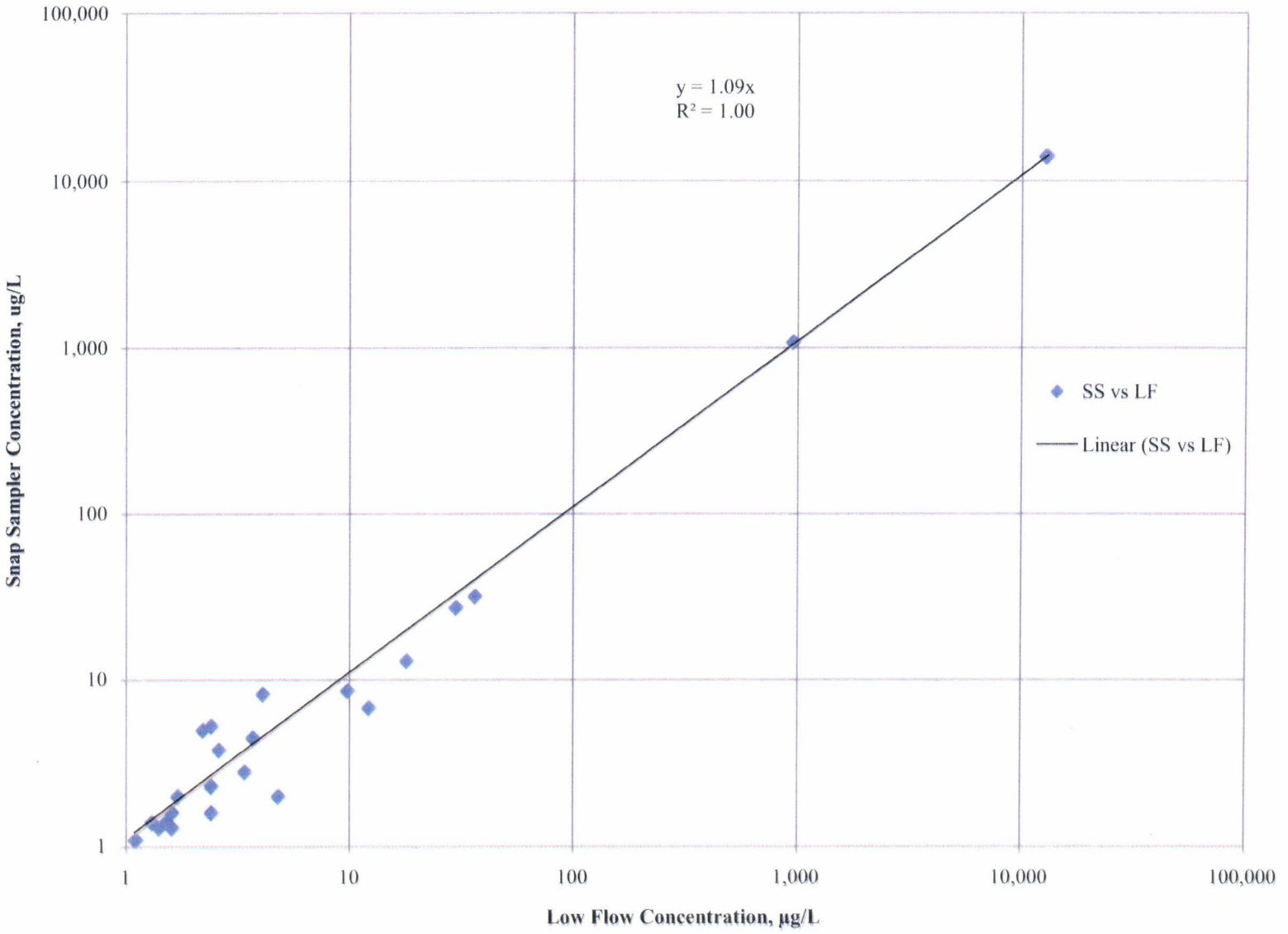


Figure 2(c): Comparison of VOC Concentrations (April and October 2010)

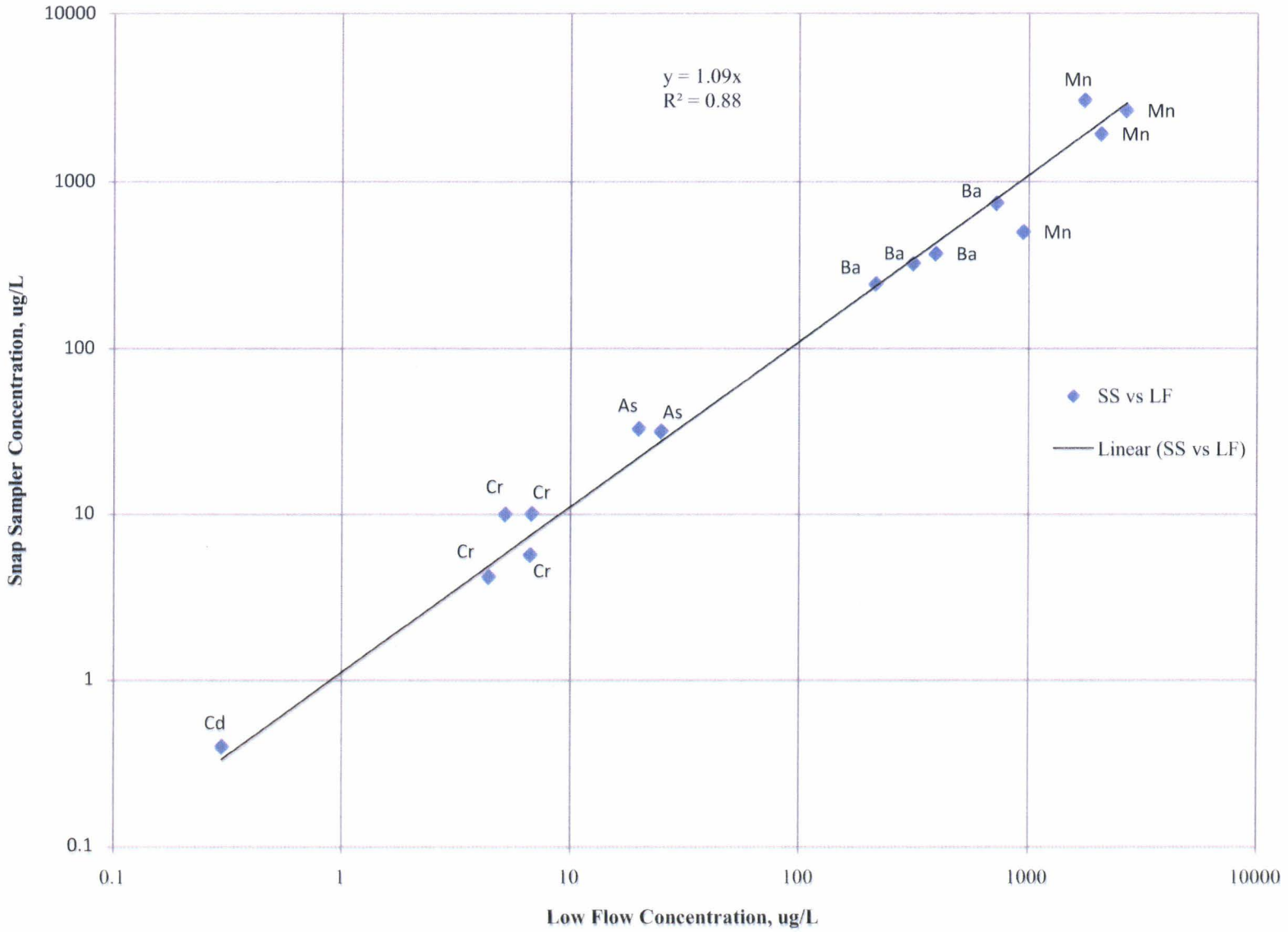


Figure 3(a): Comparison of Metal Concentrations, April 2010

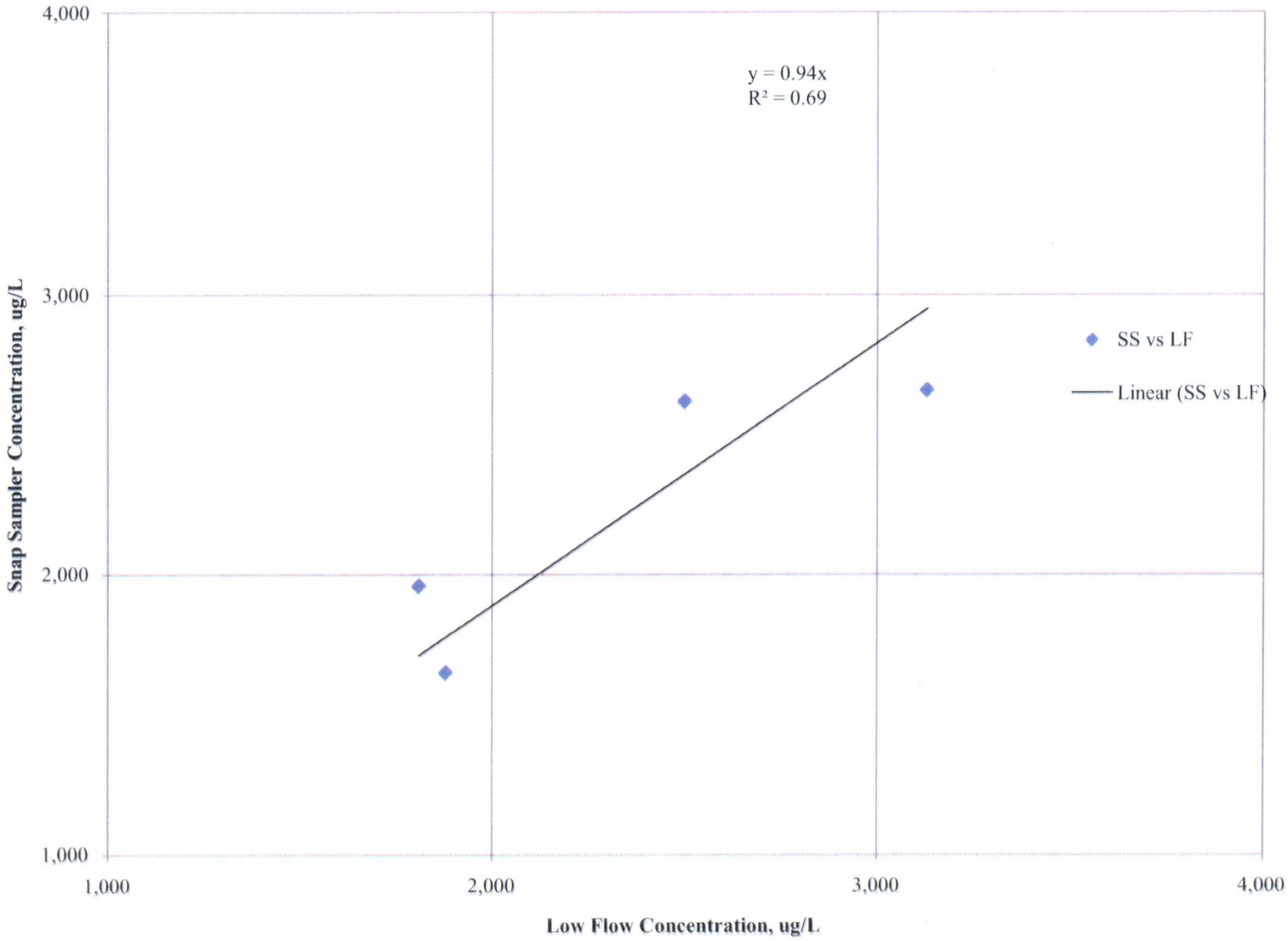


Figure 3(b): Comparison of Metal Concentrations, October 2010

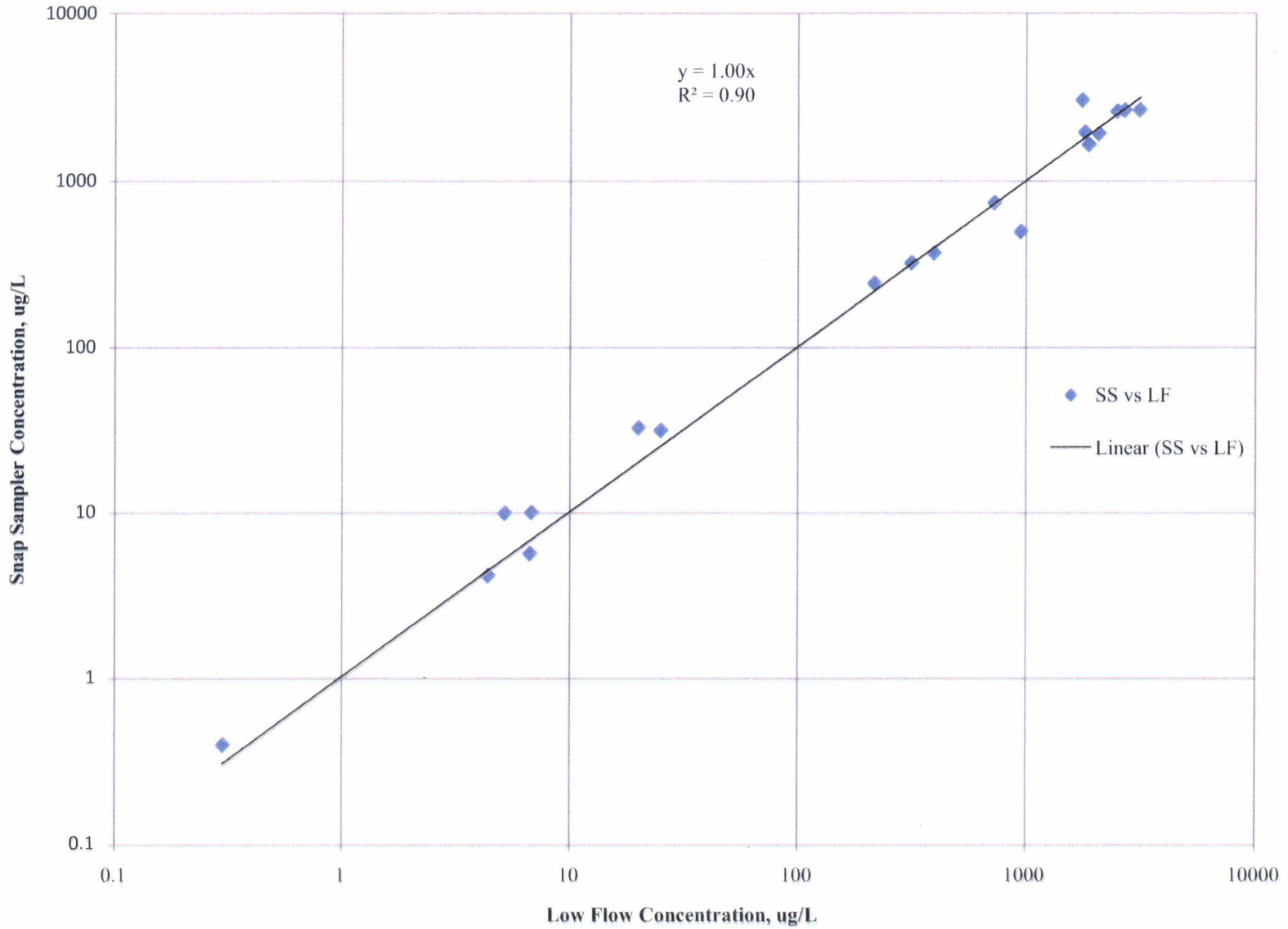


Figure 3(c): Comparison of Metal Concentrations, April and October 2010

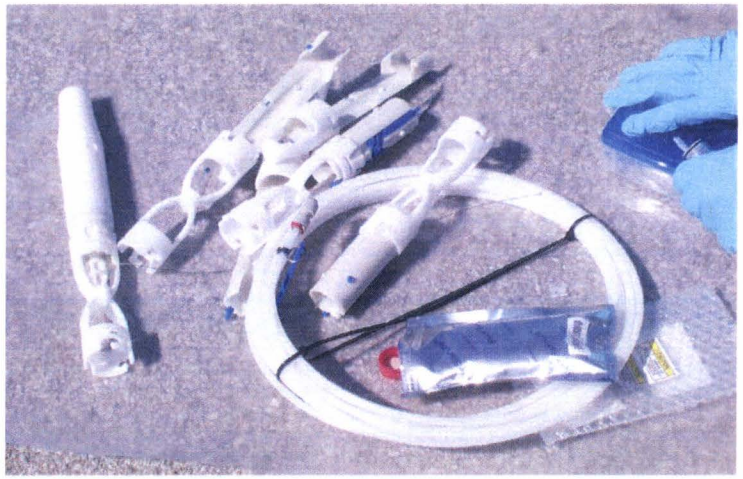


PHOTO 1: Snap Sampler Components (Bottle holders and tubing for the trigger line)

PHOTO 2: Assemby of Snap Sampler (40 ml glass vial in bottle Holder)

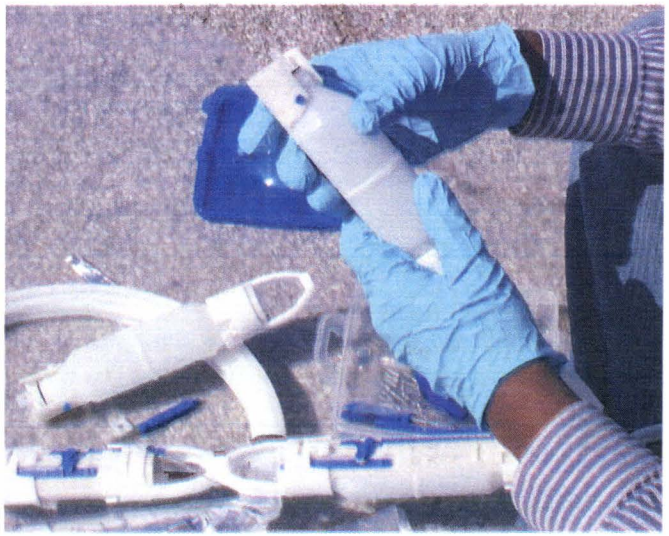


PHOTO 3: Assembly of Snap Sampler (125 ml Poly Bottle)

PHOTO 4: Assembly of Snap Sampler (Connecting Sample Holders)

PHOTO 5: Assembly of Snap Sampler

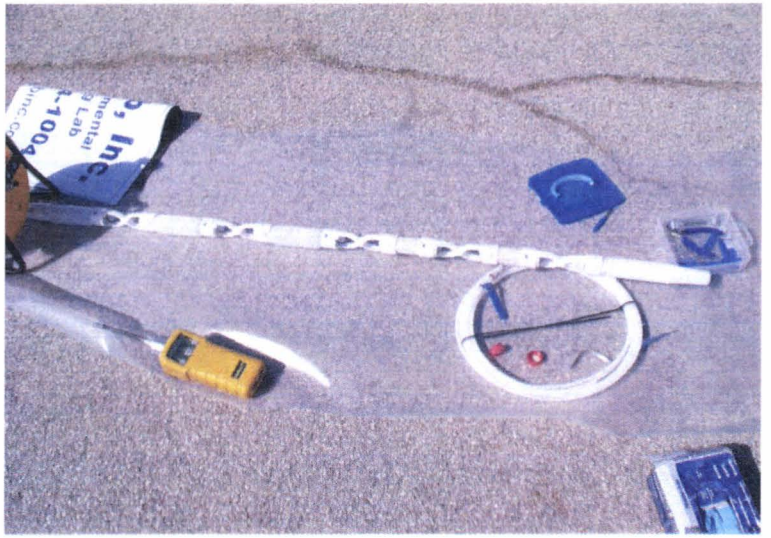


PHOTO 6: Snap Sampler Setup Ready to be Deployed

PHOTO 7: Snap Sampler Deployed (with well dock and tubing for trigger line)

PHOTO 8: Snap Sampler Installed and Well Sealed with Well Cap

PHOTO 9: Snap Sampler Retrieval

PHOTO 10: Retrieved Snap Sampler with Bottle Caps Closed

PHOTO 11: Another View of Retrieved Snap Sampler (with groundwater samples)

PHOTO 12: Typical Low-Flow Purging and Sampling Setup